EPA Grant X7-00J06201-0: Oregon Department of Forestry
Riparian Function & Stream Temperature (RipStream) Study

Product #1 - Initial analysis results for the Post-5 RipStream Analysis

I am currently structuring this analysis in a similar fashion to the Post-2 Magnitude RipStream analysis but expanded to the full 5 years post harvest. Temperature Data: I am calculating 40-day means of the daily maximum, minimum, mean, and diel fluctuation (maximum-minimum) for probes 1W, 2W, and 3W for every year. The 40 days are between July 15 and August 22. This timeframe was selected for several reasons: 1) probes were generally available, running, and had not encountered late-season low flow problems yet. 2) This period generally captures the warmest portion of the summer. I say "generally" because each stream has a different summer maximum date with fair variation. 3) I wanted a broad range of temperatures to draw an average from. The fewer days used, the greater the number of unexpected spikes and dips in the data.

Analysis structure: of concern is the change in temperature between two probes. That is, for the control reach we are concerned with the change in temperature between 1W and 2W. For the treatment reach the probes are 2W and 3W. The power of RipStream's design lies in its use of upstream control reaches and several years of pre-harvest data collection. The pre-harvest data collection allows us to understand what the treatment reach was like before alteration. However, it also provided a relationship between the upstream reach and treatment reach both before and after harvest. The analysis will likely use two parameters to generally explain changes in the treatment reach temperature: treatment reach length (streams tend to warm over distance in a downstream direction) and the change in the control reach. Including the change in the control reach allows us to incorporate into the analysis year-to-year differences in each stream's condition.

The data consist of repeated measurements from 33 sites (202 data points at present). Each data point is generated roughly 12 months apart from other points likely making it temporally independent from its sequentially neighboring points. We therefore expect to make us of a linear mixed-effects modeling procedure without a temporal autocorrelation variance structure. Preliminary examinations of the data indicate that the random effects portion of the analysis will be best served by grouping data by site. Grouping data by year does not appear supported. As far as the random effects go (i.e., the peculiarities we expect sites to differ from each other by), the Post-2 Magnitude study found strong support for a random intercept as well as a different slope for the relationship between treatment temperature change and the change in the control reach's temperature. So far, we see the same support for a random intercept. However, for reasons that need to be explored further, we are having estimation troubles for models that include a random slope for control reach temperature. We expect the relationship to remain important.

In Figure 1 we present the raw changes in maximum temperature for the treatment reach. In the Post-2 analysis shade was found to negatively relate to stream temperature warming. That is, the less shade, the greater the warming. The sites that exhibited the greatest initial loss in shade in the Post-2 analysis are circled in Figure 1. A central question for our analysis is: for instances where temperature increased following harvest, did temperature recovery occur over time, and was it linked to the recovery of (probably understory) shade?

	A	B	C	D	E	F	G	H
1		df	AIC	BIC	deltaAIC	ω		
2	PostSeqP	9	343.404	373.178	0.000	0.708		
3	PostConstP	8	345.215	371.681	1.811	0.286		
4	PostSeq	9	353.565	383.339	10.161	0.004		
5	BO	12	356.278	395.977	12.874	0.001		
6	PostConst	8	358.718	385.184	15.314	0.000		
7	upstream_TRlength	7	374.788	397.946	31.384	0.000		
8	upstream	6	379.989	399.838	36.585	0.000		
9	intercept	5	386.258	402.799	42.854	0.000		

At this moment in time we are amassing all of our post-5 shade data. A quality-control check found an error in digital hemispherical photograph processing; we had hoped at this time to present initial findings on the relationship between shade and treatment reach temperature change. The data are currently being reprocessed to correct the error.

A preliminary analysis of the data found results that were similar to those of our earlier analysis. The model structures were similarly supported (the same mixed-effects parameterization) and the results of similar magnitudes. For this analysis I constructed and compared the performance of the following models. The models are compared in Table 1.

Intercept: The treatment reach temperature change (TR) is the same for all sites. Random effects = intercept and control reach temperature, groped by site (random effects structure the same across all models).

Upstream: TR depends on the upstream control temperature.

Upstream_TR length:TR depends on the upstream control temperature and the treatment reach length.

Beyond Optimal (**BO**): TR depends on the upstream control temperature, treatment reach length, elevation, watershed area, timing (pre or post), ownership (Private, State), and the number of years post-harvest a data point is.

Postharvest Constant (**PostConst**): TR depends on the upstream control temperature, treatment reach length, and timing (pre or post). This model assumes that post-harvest changes are permanent.

Postharvest Sequential (**PostSeq**): TR depends on the upstream control temperature, treatment reach length, timing, and years post-harvest. This model allows a change (linear) in post-harvest response over time.

Postharvest Constant Private (**PostConstP**): TR depends on the upstream control temperature, treatment reach length, and an interaction between ownership and timing (PrivPost). This model assumes that post-harvest changes are permanent.

Postharvest Sequential Private (**PostSeqP**): TR depends on the upstream control temperature, treatment reach length, years postharvest, and the interaction between ownership and timing. This model allows a change (linear) in post-harvest response over time.

Table 1. AIC model comparison of the preliminary post-5 analysis models. Df = degrees of freedom, AIC = Akaike's Information Criterion (smaller = better supported), BIC= Bayesian Information Criterion, deltaAIC = difference in AIC between the best-supported (minimum AIC) model and the model under consideration. ω = model weight.

	df	AIC	BIC	deltaAIC	ω
PostSeqP	9	343.404	373.178	0.000	0.708
PostConstP	8	345.215	371.681	1.811	0.286
PostSeq	9	353.565	383.339	10.161	0.004
BO	12	356.278	395.977	12.874	0.001
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The two top models (PostConstP and PostSeqP) are both supported as the best of the set as their differences in AIC values are quite similar (less than 2 AIC). This indicates that including a parameter for temperature change following harvest does not greatly improve model fit; a constant-effects model performed about as well. There is substantially less support for models that did not differentiate between data from private sites post-harvest and all other data types. The model weighting (ω) indicates the probability that a model is the best of the set. The top two models have a joint weighting of 99%, indicating little support for any of the other models considered.

The fixed-effects parameter estimates for the best-supported model, PostSeqP, are:

Variables	Value	Std.Error	DF	t-value	p-value
(Intercept)	0.3166509	0.1297879	166	2.439757	0.0157
ControlTemp	-1.1687546	0.3335075	166	-3.504433	0.0006
PrivPost	**0.6529579**	0.1054748	166	6.190655	0.0000
TReachLength	0.7460387	0.2893230	31	2.578567	0.0149
YrsPost	**-0.0417507**	0.0207385	166	-2.013202	0.0457

The PrivPost variable has a parameter estimate of 0.65. This indicates that treatment reaches that are post-harvest on private sites are on average 0.65° C warmer than State sites post-harvest or any pre-harvest conditions. This is congruent with our previous findings. The YrsPost estimate indicates that for every year post-harvest temperature declines by -0.04° C. This is, at α=0.05, marginally significant. In the model PostConstP, in the absence of the YrsPost parameter the estimate for the parameter PrivPost is 0.54° C, essentially an average of the temperature change over the full 5 years post-harvest for private sites.

Next analysis steps: incorporate shade into the analysis, finalize the data sets for analysis (shade, vegetation, site features, temperature, downed wood), and proceed with analysis development.

Meeting grant expectations: I am currently compiling all data associated with this project including vegetation (trees, shrubs, hillside downed wood), in-stream wood volumes, shade, and channel information. Temperature data (hourly and daily) from all 9 years (2002 through 2010) are fully incorporated into a database, documented, and quality checked. The temperature and other site data will be summarized for inclusion into the mixed-effects model structure described above. By that point, the databases should be essentially complete and documented sufficiently for dissemination. The analysis will likely include a specific analysis of changes in shade over time relative to riparian characteristics. I will perform the analyses and create a report of the findings in manuscript format.